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WHAT IS CLAIMED IS:

1. A light-emitting diode comprising:

a semiconductor substrate; and

a layered structure, made of an AlGaInP type compound semiconductor material and provided on the semiconductor substrate,

wherein the layered structure comprises:

a light-emitting structure composed of a pair of cladding layers and an active layer for emitting light provided between the pair of cladding layers; and

a current diffusion layer which is lattice-mismatched with the light-emitting structure, wherein a lattice mismatch $\Delta a/a$ of the current diffusion layer with respect to the light-emitting structure defined by the following expression is -1% or smaller:

$$\Delta a/a = (a_d - a_e)/a_e$$

where a_d is a lattice constant of the current diffusion layer, and a_e is a lattice constant of the light-emitting structure.

2. A light-emitting diode according to claim 1, wherein crystal of the semiconductor substrate is inclined by 8° (8 degrees) to 20° (20 degrees) in a [011] direction with



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respect to a (100) plane thereof.

3. A light-emitting diode according to claim 1, wherein a composition of the current diffusion layer is selected in such a manner that the current diffusion layer becomes transparent with respect to a wavelength of light emitted from the light-emitting structure.

4. A light-emitting diode according to claim 1, wherein a composition of the current diffusion layer is expressed as $(\text{Al}_x\text{Ga}_{1-x})_y\text{In}_{1-y}\text{P}$, and x is set in the range of 0.01 to 0.05 and $1-y$ is set in the range of 0.01 to 0.30 in the composition.

5. A light-emitting diode according to claim 1, wherein a composition of the current diffusion layer is expressed as $(\text{Al}_x\text{Ga}_{1-x})_y\text{In}_{1-y}\text{P}$, and at least one of a value of x and a value of $1-y$ in the composition varies along a thickness direction of the layered structure.

6. A light-emitting diode according to claim 1, wherein a composition of the current diffusion layer is expressed as $(\text{Al}_x\text{Ga}_{1-x})_y\text{In}_{1-y}\text{P}$, and at least one of a value of x and a value of $1-y$ in the composition decreases in a step-like

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manner along a thickness direction of the layered structure from an interface with the light-emitting structure toward an opposite end of the current diffusion layer.

7. A light-emitting diode according to claim 1, wherein a composition of the current diffusion layer is expressed as $(\text{Al}_x\text{Ga}_{1-x})_y\text{In}_{1-y}\text{P}$, and at least one of a value of x and a value of $1-y$ in the composition varies in a step-like manner along a thickness direction of the layered structure from an interface with the light-emitting structure toward an opposite end of the current diffusion layer, thereby controlling a resistivity of the current diffusion layer in the thickness direction.

8. A light-emitting diode according to claim 5, wherein both the values of x and $1-y$ in the composition of the current diffusion layer vary, independent of each other.

9. A light-emitting diode according to claim 6, wherein both the values of x and $1-y$ in the composition of the current diffusion layer decrease, independent of each other.

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10. A light-emitting diode according to claim 7, wherein both the values of x and $1-y$ in the composition of the current diffusion layer vary, independent of each other.



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EXAMINER KANG, DONGHEE				
ART UNIT 2811		PAPER NUMBER		

DATE MAILED: 10/13/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

DOCKETED
 NUMBER # 829-617
 DATE 10/13/04
 DATE Jan 13, 2005
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Office Action Summary

Application No.

10/702,842

Applicant(s)

HIROSHI NAKATSU ET AL

Examiner

Donghee Kang

Art Unit

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --
 Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.135(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 07 November 2003.
 2a) ☐ This action is FINAL. 2b) ☒ This action is non-final.
 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 11-14 is/are pending in the application.
 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
 5) ☐ Claim(s) _____ is/are allowed.
 6) ☒ Claim(s) 11-14 is/are rejected.
 7) ☐ Claim(s) _____ is/are objected to.
 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
 10) ☒ The drawing(s) filed on 07 November 2003 is/are: a) ☐ accepted or b) ☒ objected to by the Examiner.
 Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
 Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
 a) ☐ All b) ☐ Some * c) ☐ None of:
 1. ☐ Certified copies of the priority documents have been received.
 2. ☒ Certified copies of the priority documents have been received in Application No. 09/373,544.
 3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892)
 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
 3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
 Paper No(s)/Mail Date 11/07/03
 4) ☐ Interview Summary (PTO-413)
 Paper No(s)/Mail Date. _____
 5) ☐ Notice of Informal Patent Application (PTO-152)
 6) ☐ Other: _____

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DETAILED ACTION

Continuing Domestic Data

1. Acknowledgment is made that this application is a continuation of application No. 09/373,544, filed 13 August 1999.

Information Disclosure Statement

2. Acknowledgment is made of receipt of applicant's Information Disclosure Statement (PTO-1449) filed November 7, 2003.

Drawings

3. The drawings are objected to under 37 CFR 1.83(a). The drawings must show every feature of the invention specified in the claims. Therefore, the limitation "crystal of the semiconductor substrate is inclined by 80 to 200 in a [011] direction with respect to a (100) plane" in claims 11, 12 & 14 must be shown or the feature(s) canceled from the claim(s). No new matter should be entered.

Proposed drawing correction or corrected drawings are required in reply to the Office Action to avoid abandonment of the application. The objection to the drawings will not be held in abeyance.

Claim Rejections - 35 USC § 112

4. The following is a quotation of the first paragraph of 35 U.S.C. 112:

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

5. Claims 11-12 & 14 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter

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which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. The limitation [110] direction is not supported by the specification. The specification only discloses [011] direction. The examiner interprets the [110] direction as a [011] direction.

Claim Rejections - 35 USC § 103

6. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

7. Claims 11-14 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hosoba (US 5,814,839).

Hosoba teaches a light-emitting diode, comprising (Fig.18):

A semiconductor substrate (31); and a layered structure (160) comprising an AlGaInP type compound semiconductor material (Col.40, lines 12) provided on the semiconductor substrate, the layered structure comprising:

a light-emitting structure comprising of a pair of cladding layers (62 & 64) and an active layer (63) for emitting light provided between the pair of cladding layers; and a current diffusion layer (156) comprising an AlGaInP type compound semiconductor material (Col.40, line 61), and wherein crystal of the semiconductor substrate is inclined in a [011] with respect to a (100) plane (Col.9, lines 57-59 & Col.40, lines 38-39).

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Hosoba does not explicitly teach the current diffusion layer is lattice mismatch with the light emitting structure, wherein the lattice mismatch is -1% or smaller. Note that the conductivity of AlGaInP compound layer can be changed with varying a composition of Al and/or In. Hosoba teaches the current diffusion layer having a different composition with the light emitting structure (Col.21, lines 44-47). This gives a lattice-mismatch between the current diffusion layer and light-emitting layer because of a different composition of Al and/or In. The lattice-mismatch causes a high dislocation density and the dislocation degrades the optical properties of the device. Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to minimize the lattice mismatch of the current diffusion layer with respect to the light-emitting structure in order to prohibit a high dislocation density which degrades an optical properties.

Hosoba does not explicitly teach the substrate is inclined by 8° to 20° . However, it would have been obvious to one of ordinary skill in the art at the time the invention was made to select a degree of slope in Hosoba's device since it has held that where the general condition of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skills in the art. *In re Aller*, 105 USPQ 233.

Conclusion

8. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Donghee Kang whose telephone number is 571-272-1656. The examiner can normally be reached on Monday through Friday.

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If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Eddie C Lee can be reached on 571-272-1732. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).



Donghee Kang, Ph.D.
Primary Examiner
Art Unit 2811

dhk